Wings Under Water . . . . .

hulls which plane, appear incapable of fully understanding the Hydrofin principles. Aircraft technicians, on the other hand, will be on fairly familiar ground, because most of the hydrofoil problems have their almost exact counterpart in aerofoils. We are concerned with lift, drag, lift-drag ratio, foil loading, power loading, and so forth. Even stalling and similar kinds of unattractive behaviour come into the hydrofoil picture.

The action of the Hydrofin in smooth water is fairly easy to follow, and there will probably be common agreement that "it will work." But what about waves? Here, too, Mr. Hook appears to have found the answer. At least, he can see how to deal with waves, although not in any one size of Hydrofin. The craft must be proportioned to the type of wave in which it is intended to operate, as will be obvious from an examination of the problems.

Action in Waves

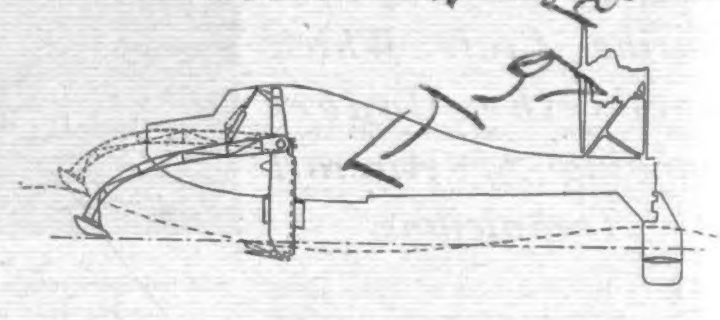
When the Hydrofin is running on its foils, there is a certain amount of clearance between the bottom of its hull and the average water level, depending on the size of the craft and the length of the struts supporting the foils. If the jockeys were entirely free to move with their supporting beams, and if the mechanism had no inertia, they would follow the surface of every little ripple (they are lightly loaded by the foils), and the whole craft would dither. The jockey beams can, however, be so controlled by springs and dampers or dashpots that the skids will skip from crest to crest on small waves, but will rise and fall with the surface of a large swell. In the former case, the craft will follow a mean curve rather than one corresponding to the water surface. In the latter, it will climb the hills and go down in the valleys. The whole thing is rather like a motor car in which the shock absorbers smooth out the smaller bumps, although the vehicle still has to follow the larger gradients.

Thus the size of wave which a Hydrofin will negotiate depends upon its length and the height of clearance between hull bottom and water surface. What constitutes a hill to be climbed by the smaller craft will be a wavelet to the large, so that the jockey skids will jump nearly from crest to crest and the craft follow a mean curve path. This skipping from crest to crest must not, of course, be overdone, or the hydrofoils might break surface. The adjustment of the damper must be such that the time lag in the dropping of the jockey skid is such that a compromise is effected between the craft following the surface of the wave in the one case and the hydrofoil breaking surface in the other.

Lest it be thought that all this is theorizing, it should be pointed out that Mr. Hook has been at work on these problems for many years; he has built many models and two full-sized craft. The first of the latter was built and tested in Africa, the second built at Cowes and tested in the Solent. The story of these efforts is one of struggle against great odds, but there is no room to tell it here, and we must confine ourselves to results.

After being rebuffed in many other quarters, Mr. Hook received his first real encouragement from the Royal Aircraft Establishment at Farnborough. Tests were made there on a 3ft model supplied by Mr. Hook. The tests were part of a general hydrofoil research programme, and were made to determine the stability of a hydrofoil system with incidence control. The model was tested in the Farnborough tank, both in calm water and in waves. One of our pictures shows the model. It will be seen that it is not very "clean" hydrodynamically, but it performed in the way Mr. Hook had predicted. That cavitation occurred in certain circumstances is scarcely to be wondered at when it is pointed out that the hydrofoils were merely flat plates with leading and trailing edges filed down thin.

Drag measurements were taken by towing the model from the nose by a length of string. As was to be expected, there was a "hump" in the drag curve in the transition region, where the lift was being transferred from the hull to the foils. By partly feathering the foils, as would be done in a full-size craft, the drag was reduced from 1.03 lb to 0.71 lb at a speed of 2.8ft/sec, and from 1.17 lb to 0.85 lb at 4.2ft/sec. After that, the craft became "foilborne," and at 6.3ft/sec the L/D ratio was 6.33, rising to 6.62 at 8.4ft/sec. After that, the drag increased approximately as V^2. The model weight to which these figure correspond was 5.45 lb.



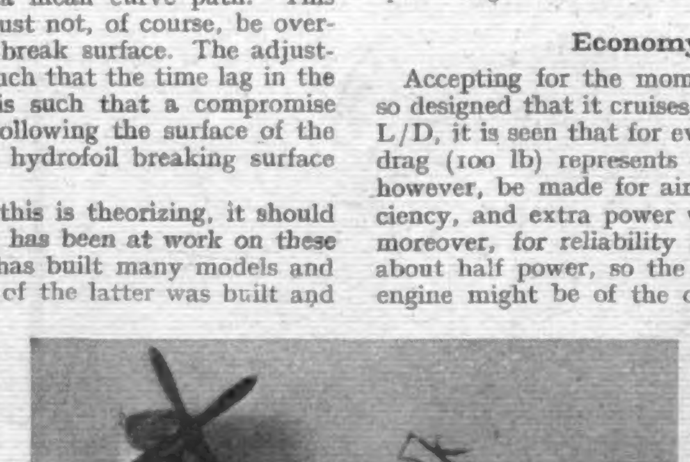
Action of a front hydrofoil and its associated "jockey skid," which serves as predictor and controller. The front hydrofoils and their jockey skids work independently, thus providing stability in roll.

In view of the relative roughness of the model (it was built to test the stability, which was proved, and not for maximum efficiency), an L/D ratio of more than 6 is not too bad. It should, however, be capable of considerable improvement, and the Farnborough report on the tests expresses the view that in full size, and with hydrofoils and their supporting struts given sections appropriate to the work, an L/D ratio of 10 : 1 should be attainable at a speed of 50 knots

Economy of Operation

Accepting for the moment an L/D of 10, and a craft so designed that it cruises at 50 knots (57.5 m.p.h.) at this L/D, it is seen that for every 1,000 lb of gross weight, the drag (100 lb) represents 15.3 h.p. An allowance must, however, be made for airscrew (or water propeller) inefficiency, and extra power will be required for "take-off"; moreover, for reliability it will be desirable to cruise on about half power, so the actual power required from the engine might be of the order of 40 h.p. per 1,000 lb of gross weight, or some 90 h.p. per ton. In terms more familiar in aviation, the power loading could certainly be as high as 25 lb/h.p. for a cruising speed of 50 knots.

It seems reasonable to suppose that the ratio of payload to gross weight would be better than is obtained in aircraft. The hydrofoils are of very small area, and even if made of solid metal they would hardly weigh as large a proportion of the structure weight as do the wings of an aircraft. The power per pound of gross weight is less than half of that used in aircraft, so engine weight should also be a smaller proportion. Fuel weight would



The Hydrofin model tested at Farnborough. Auxiliary hydrofoils are mounted above the main ones and rise above the water when the craft is running.